DECLARATION

I,Noboru YOSHIDA, of SHIGA INTERNATIONAL PATENT OFFICE, 2-3-1, Yaesu, Chuo-ku, Tokyo, Japan, understand both English and Japanese, am the translator of the English document attached, and do hereby declare and state that the attached English document contains an accurate translation of the official certified copy of Japanese Patent Application No. 2000-188297 and that all statements made herein are true to the best of my knowledge.

Declared in Tokyo, Japan

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[Document Type] SPECIFICATION

[Title of the Invention] METHOD FOR REDUCING FRICTIONAL RESISTANCE OF SHIP BODY, AND FRICTION REDUCING SHIP

[Claims]

[Claim 1] A method for reducing frictional resistance of a ship body by ejecting gas bubbles on a submerged surface of the ship body, comprising:

creating in the water a negative pressure region, having a pressure lower than a pressure in a gaseous space, resulting from the ship body cruising through the water; directing a gas from the gaseous space to the negative pressure region in the water; and generating a circulating flow in the water which increases the negative pressure region by means of a wing.

[Claim 2] A friction reducing ship that reduces frictional resistance of a ship body by ejecting gas bubbles on a submerged surface of the ship body, comprising:

a negative pressure forming section provided on the submerged surface of the ship body for creating in the water a negative pressure region having a pressure lower than a pressure in a gaseous space;

a discharge opening disposed at the rear of the negative pressure forming section for ejecting the gas bubbles towards the negative pressure region in the water;

a fluid passage having one end open to the gaseous space and having the other end open in the water by way of the discharge opening; wherein

the negative pressure forming section is provided with a wing shaped component whose cross sectional shape is formed in a wing shape.

[Claim 3] A friction reducing ship according to claim 2, wherein the wing shaped component is disposed so as to generate an uplifting force.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

This invention relates to a method of reducing frictional resistance by reducing the frictional resistance of a ship body and to a friction reducing ship, and in particular, improves the overall energy efficiency by efficiently ejecting bubbles into the water.

[0002]

[Prior Art]

Conventionally, methods have been proposed for the purpose of reducing the energy costs when a vessel or the like is cruising, in which bubbles are ejected into the water and frictional resistance between a ship body and the water is reduced by interposing a multitude of bubbles in the vicinity of the surface (submerged surface) of the outer hull of the ship body.

[0003]

Techniques of generating bubbles in the water are proposed in Japanese Unexamined Patent Applications, First Publication Nos. Sho 50-83992, Sho 53-136289, Sho 60-139586, Sho 61-71290, and in Japanese Unexamined Utility Model Applications, First Publication Nos. Sho 61-39691 and Sho 61-128185.

[0004]

In these techniques, methods for generating bubbles in the water rely on equipment such as pumps and blowers to eject pressurized gas into the water through a plurality of holes or porous plates provided on the ship body.

[0005]

[Problems to be Solved by the Invention]

However, the method of ejecting pressurized gas into the water presents a problem in that energy is needed in operating the pressurizing equipment so that it results in a loss of part of the energy savings achieved by reducing the frictional resistance. Especially, if the gas is ejected into the water from relatively deep locations below the surface such as at the bottom surface of large capacity vessels, it is necessary to pressurize the gas to a higher pressure relative to the water pressure (static pressure), thus resulting in expending a large amount of energy. Also, when providing pressurizing equipment in the ship body, high costs such as installation and operating costs are generated.

[0006]

This invention is provided in view of the above circumstances, and the objectives of the invention are as follows.

(1) To effectively reduce the energy consumption during cruising by lowering the frictional resistance at a lower energy consumption.

(2) To mix bubbles into the water efficiently to achieve effective reduction in frictional resistance.

(3) To reduce the cost of constructing the ship body.

[0007]

[Means for Solving the Problems]

In order to solve the above-mentioned problems, the invention according to claim 1 adopts, in a method that reduces frictional resistance in which the frictional resistance of a ship body is reduced by ejecting gas bubbles on a submerged surface of the ship body, a technique for creating in the water a negative pressure region having a pressure lower than a pressure in a gaseous space resulting from the ship body cruising through the water, directing a gas from the gaseous space to the negative pressure region in the water, and

generating a circulating flow in the water which increases the negative pressure region by means of a wing.

Furthermore, the invention according to claim 2 adopts, in a friction reducing ship for reducing the frictional resistance of a ship body by ejecting bubbles on the submerged surface of the ship body, a technique of providing a negative pressure forming section provided on the submerged surface of the ship body which creates a negative pressure region in the water having a pressure lower than a pressure in a gaseous space, a discharge opening provided at the rear of the negative pressure forming section which ejects bubbles toward the negative pressure region in the water, and a fluid passage having one end open to the gaseous space and having the other end open to the water by way of the discharge opening, wherein the negative pressure forming section is provided with a wing shaped component whose cross sectional shape is formed in a wing shape.

Furthermore, the invention according to claim 3 adopts, in the friction reducing ship of claim 2, a technique of disposing the wing shaped component so as to generate an uplifting force.

[0008]

According to this invention, since a negative pressure region is formed in the water having a pressure lower than a pressure in a gaseous space resulting from cruising of the ship body in the water, a gas is directed from the gaseous space into the water and bubbles are ejected into the water by means of a pressure gradient force. At this time, by increasing the negative pressure region by generating a circulating flow in the water by means of a wing, a large volume of gas is directed into the water by increasing the pressure gradient force. Furthermore, by causing an uplifting force to act on the ship body due to this circulating flow, it is possible to reduce the submerged surface area of the

ship body.

[0009]

[Embodiments of the Invention]

Below, an embodiment will be described with reference to the figures, wherein the friction reducing ship according to this invention is applied to a bulk ship such as a tanker or freighter. In Fig. 2, reference symbol M is a friction reducing ship, 10 is a ship body, 11 is a bubble generation apparatus, 12 is a ship body outer hull (submerged surface), 13 is a screw, 14 is a rudder, and 15 is the water surface (waterline).

[0010]

A VLCC (Very Large Crude Oil Carrier), for example, corresponds to the bulk ship as the friction reducing ship M. In comparison with other types of vessels, the surface area on the bottom of the ship is formed to be relatively large in comparison with the side of the ship in the ship body outer hull 12 (submerged surface) which is beneath the waterline 15. Moreover, the bubble generation apparatus 11 is disposed at the front of the ship body 10 (bow side).

[0011]

As shown in Fig. 2(b), the bubble generation apparatus 11 is constituted by a fluid guiding body 20 disposed at an opening 12a provided on the bottom of the ship, and an air induction pipe (AIP) 21 connected to this fluid guiding body 20.

[0012]

The fluid guiding body 20 is constructed overall as a component member of a pipe-shape having a hollow internal section, and flanges 22, 23 for connecting to the air induction pipe 21 or to the ship body outer hull 12 are provided at both ends in the axial direction. Also, at the end of the side connected to the ship body outer hull 12 (lower end)

is provided an inclined surface 24 (or curved surface) projecting from the submerged surface 12 of the ship body and inclined with respect to the axial direction facing the front of the ship body (bow side). The inclined surface 24 is provided such that the height from the submerged surface 12 of the ship body gradually increases in the direction of the stern. Furthermore, a side surface 25 at the rear of the inclined surface 24 is provided with a discharge opening 26 comprising a through-hole facing the rear of the ship body (stern side) serving as a hollow opening for the fluid guiding body 20. Moreover, wing shaped components (wings 30, 31, 32) formed in a wing shaped cross section are disposed in front of the inclined surface 24.

[0013]

In other words, as shown in Fig. 3 and Fig. 4, a first wing 30 disposed at a prescribed spacing from and roughly parallel to the submerged surface 12 of the ship body (see Fig. 2) and second wings 31, 32 which support the first wing 30 by being disposed between the first wing 30 and the ship body outer hull 12 are provided at the front part of the fluid guiding body 20.

[0014]

Various wing shapes such as a NACA wing type, ogival wing type, etc., can be applied as the shape of the wings 30, 31, 32, and the shape is chosen in accordance with the shape of the ship and its cruising speed. Also, the first wing 30 is disposed in such a way that the front edge 30a and the rear edge 30b are oriented in the forward direction Dve of the ship body, the wing surfaces 30c (see Fig. 2(b)) and 30d are oriented in the up- and down-directions, and further, it is disposed such that an uplifting force acts during cruising (such that, during cruising, the flow velocity at the wing surface 30c which is directed upward is large in comparison with that at the wing surface 30d which is directed

downward). A curved water passage 35 which is recessed and directed vertically upward is formed along the forward direction Dve of the ship body.

[0015]

Returning to Fig. 2, the air induction pipe (AIP) 21 is constituted primarily of pipe shaped members, and is installed roughly through the ship body 10 and is connected to the fluid guiding body 20 via a flange 27. By connecting the air induction pipe 21 and the fluid guiding body 20, a fluid passage 36, serving as the internal space thereof, is formed. The fluid passage 36 is open at one end to a gaseous space (atmosphere) by way of an air intake opening 21a of the air induction pipe 21, while the other end opens into the water by way of the discharge opening 26. Here, the cross sectional area and shape of the fluid passage 36 (internal space of the fluid guiding body 20 and the air induction pipe 21) are set so that a desired amount of the fluid flows at a low pressure loss.

[0016]

Here, the shape and positioning of each component of the fluid guiding body 20 are designed by flow field analysis of CFD (Computational Fluid Dynamics) so as to obtain the desired shape of the flow of water in the fluid guiding body 20 during cruising.

[0017]

In other words, the protruding height of the inclined surface 24 of the fluid guiding body 20 from the submerged surface 12 of the ship body is set so that a negative pressure region having a pressure lower than that of the gaseous space (atmosphere) is formed in the water at the back side of the fluid guiding body 20 by the flow of water relative to the ship body 10, during cruising at a prescribed speed Vs, for example. Further, a flow circulating around the wings 30, 31, 32 is generated by the wings 30, 31, 32, and they are designed so that the flow velocity of the water circulating along the inclined surface 24 of

the water passage 35 and the fluid guiding body 20 is increased by the circulating flow.

[0018]

Further, as the material of the fluid guiding body 20 and the air induction pipe 21, those which provide a surface which is corrosion resistant primarily with respect to sea water and which is resistant to attachment of marine organisms, such as metals which have undergone some corrosion resistant treatment, or resins, etc., are preferably used. Reference symbol 28 shown in Fig. 2(b) is packing for the connecting flanges.

[0019]

Next, a method of reducing the frictional resistance of a ship body by means of the friction reducing ship M constituted as described above will be explained with reference to Fig. 1.

In the stationary state of the ship, water (seawater) ingresses into the fluid passage 36 (the internal space of the fluid guiding body 20 and the air induction pipe 21 shown in Fig. 2) to about the same level as that surrounding the ship body 10. When the ship body 10 begins to cruise using the thrust of the screw 13 (refer to Fig. 2), a flow of water 40 relative to the ship body 10 is formed.

[0020]

In the cruising state, at the bottom of the ship, the water passage is narrowed by the inclined surface 24 of the fluid guiding body 20 so that the flow velocity of water flowing along the bottom of the ship increases, and the acute angle of the protruding end of the inclined surface 24 forms a separation layer in the water. Such actions lead to local lowering of the static pressure in the water at the back side of the inclined surface 24.

[0021]

Then, when the cruising speed of the ship body 10 reaches a certain ship speed Vs

(standard cruising speed, for example), a negative pressure region 41, having a lower pressure relative to the atmosphere, is formed in the water at the rear of the inclined surface 24.

[0022]

In this case, compared with the pressure at the air intake opening 21a, the pressure at the discharge opening 26 facing the negative pressure region 41 is low so that the fluid (seawater and air) inside the fluid passage 36 is subjected to a pressure gradient force such that the seawater is discharged from the fluid passage 36 and the air flowing in from the air intake opening 21a is ejected into the water by flowing through the fluid passage 36.

[0023]

Then, the gas ejected into the water becomes mixed in the water as air bubbles 42, and numerous bubbles 42 intervene in the vicinity of the submerged surface 12 of the ship body 10 leading to a reduction in the frictional resistance of the ship body 10.

[0024]

The energy required to eject the air into the water is primarily the energy for changing the position of the air. This energy is obtained by varying the flow conditions of the water by means of the inclined surface 24 of the fluid guiding body 20 protruding from the submerged surface 12 of the ship body, and is less than the energy consumed in ejecting the compressed gas into the water. For this reason, the energy expended in cruising is effectively reduced by lowering the frictional resistance of the ship body 10.

[0025]

Also, in this embodiment, the acute angle of the protruding end of the lateral surface 25 generates not only a separation region but also cavitation. For this reason, gas

and water are mixed vigorously at the interface between the gas and the liquid due to the stirring actions caused by the separation region and cavitation to promote detachment of the bubbles 42 from the gas/liquid interface.

[0026]

Further, in this embodiment, the wings 30, 31, 32 are disposed in the front section of the fluid guiding body 20, and a circulating flow Γ is generated around the wings 30, 31, 32. That is, as shown in Fig. 1(b), a circulating flow Γ flowing towards the stern of the ship is formed around the first wing 30 along the wing surface 30c at the water passage 35 side, and flowing towards the bow of the ship along the wing surface 30d on the opposite side. In such a case, on the wing surface 30c of the water passage 35 side, the flow velocity is increased by the addition of the circulating flow Γ to the water flow of water 40 flowing along the submerged surface 12, thereby the flow velocity of the water flowing along the inclined surface 24 is increased and the static pressure at the negative pressure region 41 is further reduced. Therefore, the pressure gradient force on the fluid in the fluid passage 36 is increased, and a large amount of air (bubbles) is ejected into the water. Although not shown in Fig. 1, since a circulating flow is similarly generated at the second wings 31, 32, the flow velocity of the water flowing along the water passage 35 and inclined surface 24 further increases.

[0027]

That is, the circulating flow Γ generated around the wings 30, 31, 32 increases the flow velocity at a protrusion end P of the inclined surface 24 to increase the negative pressure region 41, and the suction force of the bubbles 42 into the water is increased. Accordingly, numerous bubbles 42 ejected into the water intervene at the submerged surface 12 to lead to an effective reduction in the frictional resistance. Also, the

circulating flow Γ is formed even during low-speed cruising (for example, about 10 knots), and therefore, reduction effects of frictional resistance can be improved over a wide range of cruising speeds.

[0028]

Also, in this embodiment, a pressure differential is generated above and below the first wing 30 due to the circulating flow Γ around the first wing 30, and an upward lift force Lf acts on the ship body 10 by way of the first wing 30. Then, due to the lift force Lf, the bow section of the ship body 10 in particular is lifted, and the submerged surface area of the ship body 10 is decreased to further reduce the frictional resistance of the ship body 10.

[0029]

Further, in the formation of the negative pressure region 41, the shape and Reynolds number of the fluid guiding body 20 (wings 30, 31, 32, inclined surface 24, etc.) are the primary governing factors, and disadvantages arising from the water depth are less likely to occur, so that the technology of this invention can be favorably applied to bulk ships.

[0030]

Here, the bubbles 42 mixed into the water are formed at a lower internal pressure than the static pressure resulting due to the water depth so that, when the bubbles 42 are moving through a constant water depth (for example, when the bubbles move along the bottom of the ship), a large water pressure acts on the bubbles 42 as they separate from the negative pressure region 41 so that the size of the bubbles 42 is gradually reduced. According to the results of research by the present applicants, it has been found that relatively smaller bubbles are preferable in reducing frictional resistance of the ship body.

[0031]

Also, because a higher pressure acts on the bubbles 42 as they separate from the negative pressure region 41, the bubbles 42 generated by the negative pressure effects are less likely to be dispersed compared with the conventional compression method. Therefore, the bubbles 42 are relatively less likely to be detached from the submerged surface 12 of the ship body so that the amount of bubbles 42 occupying specific regions near the bottom of the ship is increased. According to the results of research by the present applicants, a larger volume of bubbles within specific regions is more preferable in reducing the frictional resistance of the ship body, and the effect of bubbles near the submerged surface 12 is higher. These facts indicate that the bubbles generated by the negative pressure effects described above are advantageously at work in reducing the frictional resistance. Therefore, frictional resistance reduction effects can be further improved by disposing a plurality of fluid guiding bodies 20 as described above in accordance with the width of the bottom of the ship, and by ejecting the bubbles from a plurality of locations on the bottom of the ship.

[0032]

Also, the bubble generation apparatus 11 has a simple constitution, and a device for compressing gas is not required so that it is obvious that the construction cost of the ship body 10 is less.

[0033]

Also, the shapes and combination of each component shown in this embodiment are just examples, and various modifications within the scope of this invention based on design requirements are possible. For example, in the above embodiment, an example of applying this invention to a bulk ship is given, but it is not limited to such an application, and it is applicable to other ships such as high-speed ships and fishing vessels.

Furthermore, the size, number and location of the bubble generation apparatus 11 are appropriately chosen according to the shape of the ship body.

[0034]

[Effects of the Invention]

As described above, according to this invention, by forming a negative pressure region in the water, use can be made of a pressure gradient force, gas can be ejected into the water at a lower energy consumption as compared with compressing the gas, and it is possible to carry out reduction in frictional resistance. Furthermore, by increasing the negative pressure region by generating a circulating flow due to wings in the water, it is possible to increase the volume of bubbles mixed in the water. Moreover, by making a lifting force act on the ship body by means of the circulating flow, it is possible to reduce the submerged surface area of the ship body. Accordingly, it is possible to implement an effective reduction in frictional resistance and reduce the energy consumption during cruising.

[Brief Description of the Drawings]

[Figure 1] This is a conceptual drawing showing an example of a method for reducing the frictional resistance of a ship body using the friction reducing ship according to this invention.

[Figure 2] This is a structural diagram schematically showing one embodiment of applying the method of reducing frictional resistance of a ship body according to this invention to a vessel.

[Figure 3] This is a perspective view showing a part of a fluid guiding body.

[Figure 4] This is a view from arrow A shown in Fig. 2.

[Brief Description of the Reference Symbols]

M friction reducing ship

Γ circulating flow

10 ship body

11 bubble generation apparatus

12 ship body outer hull (submerged surface)

15 water surface (waterline)

20 fluid guiding body (negative pressure forming section)

21 air induction pipe

24 inclined surface

26 discharge opening

30, 31, 32 wings (wing shaped components)

36 fluid passage

40 flow of water

41 negative pressure region

42 bubbles

[Document Type] Abstract

[Abstract]

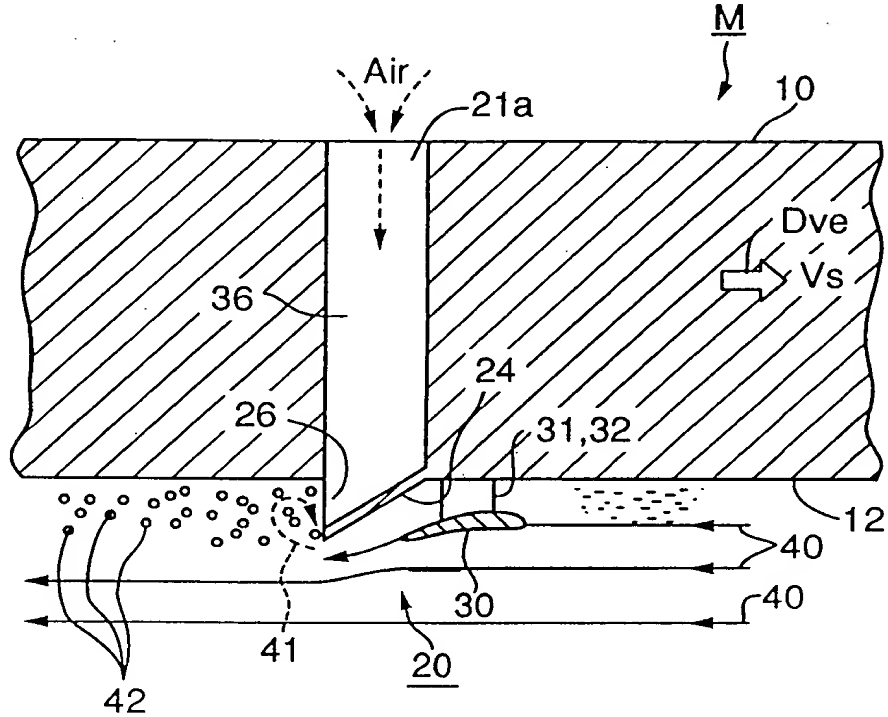
[Problem] To provide a method for reducing frictional resistance of a ship body and a friction reducing ship, in which it is possible to effectively reduce the energy consumption during cruising by carrying out reduction of frictional resistance at a low energy consumption.

[Means for Solving the Problem] A negative pressure region 41 is formed in the water having a pressure lower than that in a gaseous space resulting from a ship body 10 cruising through the water, a gas is directed to the negative pressure region 41 in the water from the gaseous space, and a circulating flow Γ is generated in the water which increases the negative pressure region 41.

[Elected Drawing] Figure 1

FIG. 1

(a)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Dve
Vs
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31,32
12
40
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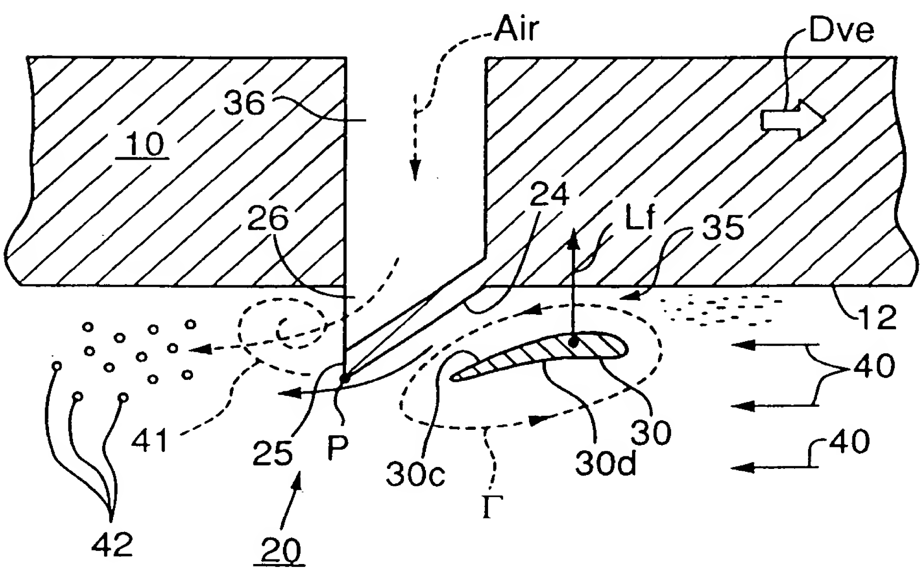
40
41
20
42

(b)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10
24
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41
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P
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30d
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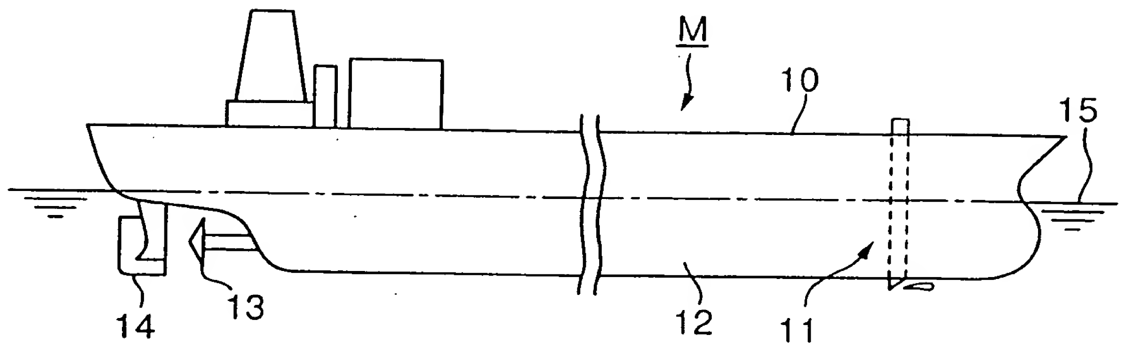
Γ
40
42
20

FIG. 2

(a)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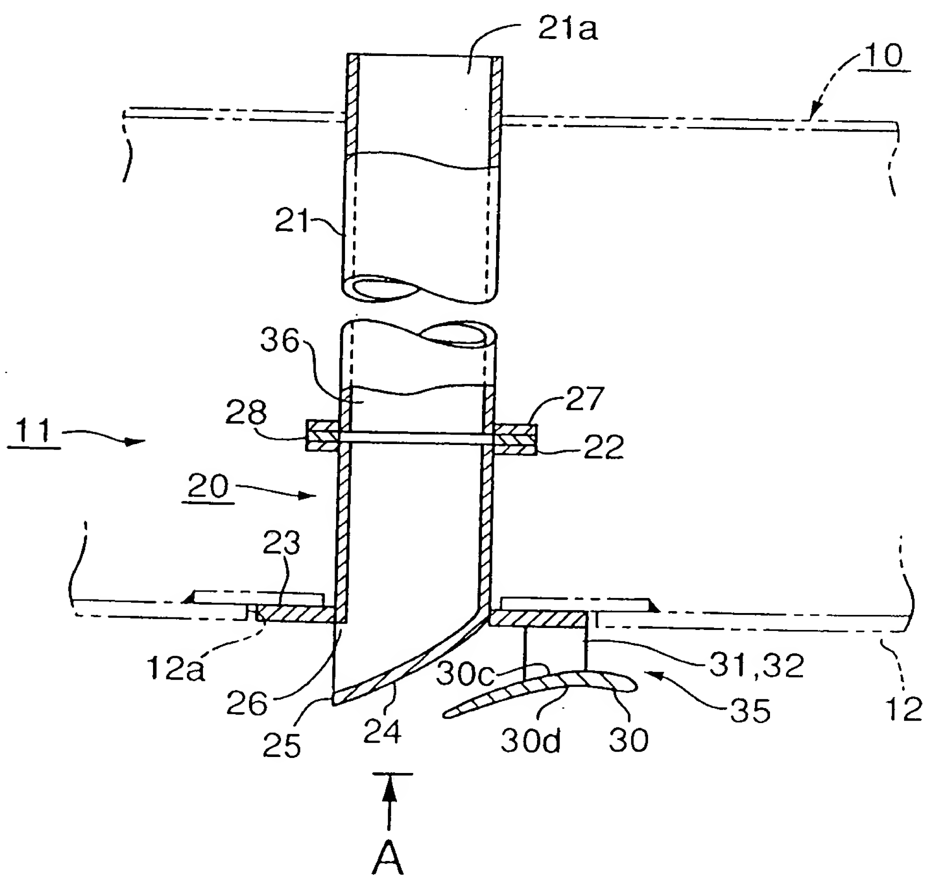
11

(b)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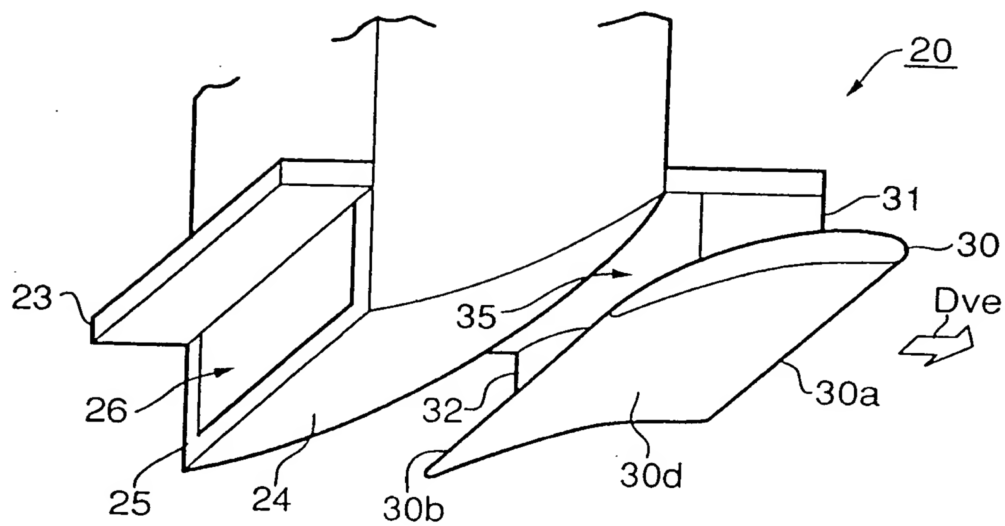
12
A

FIG. 3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32
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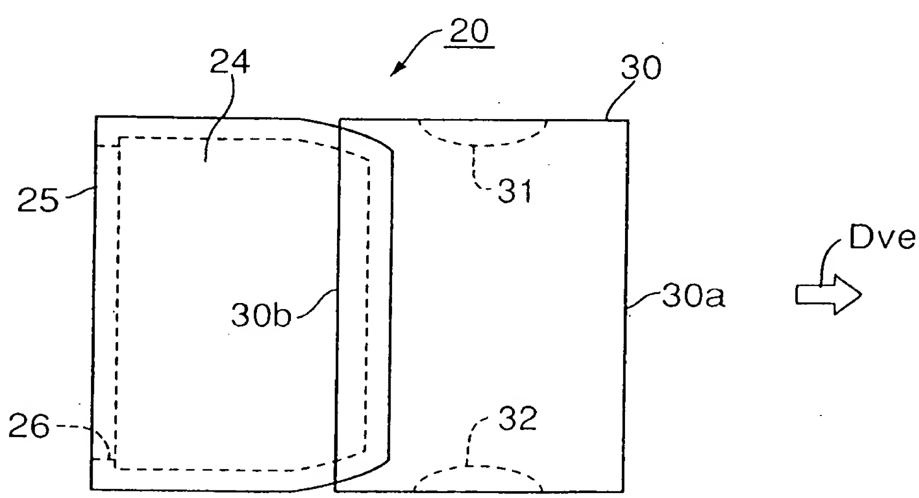
25
24
30b
30d

FIG. 4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